Does Son Preference Influence Children's Growth in Height? A Comparative Study of Chinese and Filipino Children

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Abstract

We compare children's growth trajectories in height in China and the Philippines, two countries with very different histories of son preference, using longitudinal survey data from the China Health and Nutrition Survey and the Cebu Longitudinal Health and Nutrition Survey. Our individual growth models show that boys' advantage in growth in height over girls is greater in China, where the level of son preference is higher, than that in the Philippines, where level of son preference is low. Our research bridges a gap in the current literatures of demography and social stratification and completes the emerging life course picture of how gender inequality is being reproduced from life stage to life stage, and from generation to generation.

INTRODUCTION

Son preference, which is still prevalent in many parts of the world, has a serious impact on the on the health and wellbeing of girls and women. China is one of the societies with a strong historical tradition of son preference (Lee and Feng 1999); despite the drastic social changes brought about first by the Communist Revolution in 1949 and then by the Economic Reform in 1979, that tradition survives in many parts of the country and still influences family decision-making. Past research suggests that female infanticide, gender selective abortion, and gender selective birth misreporting are prevalent in some parts of China, especially in rural areas (Ren 1995), and these factors are largely responsible for the increasingly unbalanced sex ratio at birth. Filipino parents, on the other hand, appear to value boys and girls much more equally than many Chinese families do, and more typical sex ratios at birth reflect this difference (Bautista 1988; Mason 1987). Many investigators have identified traditional family structures as a root cause of societal differences in son preference. The traditional bilineal family structure in the Philippines means that people expect both sons and daughters to help parents in their old age, while the traditional Chinese family is patrilineal, and responsibility for elderly parents falls to the sons (De Vos 1985). In China, interdependencies between persons are generally confined to the stem family, and residually to the brothers of the same father, while in the Philippines such interdependencies can extend beyond the nuclear or stem family to neighbors or other kin, making elderly parents less dependent on children of either sex (De Vos 1985).

However, son preference is more than just cultural inertia; it has deep roots in the socioeconomic and institutional structure of a society, and it changes with the institutional environment. There has been considerable attention to the nature of son preference in China and the way it has been shaped by social and economic changes over the past several decades. Son preference dates back to the origins of ancestral worship thousands of years ago, supported by the imperial state and the Confucian ideology (Lee and Wang 1999). The first 30 years of the People's Republic of China witnessed a steady decline of son preference, largely due to the government's continuous effort to promote gender equality. The command economy and authoritative political system together ensured that state policies, including those designed to promote gender equality, could be implemented with few compromises (Banister 2004). The economic reform and decollectivization since the late 1970s have on the one hand increased the value of children's labor, especially male children, and restored the central role of male household heads in allocating resources (Li 2004); on the other hand, they weakened the state's capability to interfere people's domestic lives (Davis and Harrell 1993). Furthermore, the family planning policies implemented since the 1970s have, if anything, intensified gender discrimination at birth, as parents attempt to bear a son within a smaller target family size (Chu 2001; Li, Feldman and Li 2000). Even after birth girls receive poorer treatment in some Chinese settings.

By contrast, according to Bautista (1988) the Philippines has long been characterized by more egalitarian treatment of boy and girl children. For example, in the rural Philippines land has been given preferentially to sons because of the domination of male labor in rice farming, while parents have invested more in the schooling of their daughters because returns to female schooling have risen in the non-agricultural sector (Quisumbing 1994). One analysis shows that this differential pattern of investment in sons and daughters leads to similar annual incomes and life-cycle incomes (Estudillo, Quisumbing and Otsuka 2001).

How does son preference influence children's health and wellbeing? More specifically, how does son preference generate gender inequality in children's health and wellbeing? In the most extreme cases, parents resort to sex-selective abortion or sex-selective infanticide to eliminate “unwanted” children, usually girls (Banister 2004; Hudson and Boer 2004). Such behaviors are motivated largely by economic factors: for example, the dowry girls must take to their marital family is too high, a family already has too many children to feed, or they desired a son but had a daughter instead. Other factors may also play roles by interacting with economic reasons. The One-Child policy in China, for example, imposes a heavy fine, along with other forms of punishment, on those who violate the regulations[1]. For families who desire sonse but have several daughters, the incentive to resort to sex-selective abortion or female infanticide increases as parity rises. The One-Child policy did not create the problem of sex-selective abortion or female infanticide, but it exacerbated the situation by significantly lowering the threshold (Banister 2004). The impacts of son preference on children’s health and wellbeing also take less extreme forms. For example, Graham et al. (1998) report that girls were breastfed for significantly shorter periods than boys, especially among higher-parity girls; Short et al. (2001) report that girls receive less care from parents than boys. The impact of the extreme forms of son preference (sex-selective abortion and infanticide) on children’s health and wellbeing has been well documented. Much less is known about the impact of the less extreme forms of son preference, such as neglect or unequal allocation of resources to girl children, which are presumably more prevalent (because they are less controversial and are less risky), thus may impact more children.

[1] The policy varies from place to place, from one child per couple, to one and a half children per couple. For ethnic minority groups, the policy allows two children per couple (Short and Zhai 1998).

The impacts of both extreme and less extreme forms of son preference are difficult to measure, albeit for different reasons. Sex-selective abortion and infanticide are highly sensitive issues and illegal in most modern societies. Admitting such acts is likely to have serious repercussions including demoralization, and even criminal charges. In this case, even though it is clear what one wants to measure, it is challenging to obtain honest answers and the whole story from individuals in a survey setting (Merli and Raftery 2000). As for the less extreme form of son preference, the problem changes from "how to measure" to "what to measure?" There are three things that worth noting. First of all, unlike the unambiguous life and death outcome in the case of sex-selective abortion or infanticide, less extreme forms of son preference appear and work in disctinct ways. For example, some parents breastfed boys longer than girls (Graham et al. 1998), others spent more time caring for boys than for girls (Short et al. 2001), some parents gave boys better food than girls, others have girls rather than boys help with household work at a young age. Despite their differences, these behaviors all have influences on the health and wellbeing of the boys and girls involved. What is needed is an indicator that can capture the influences of all these drastically different forms of gender discriminatory behaviors.

The second difference between extreme demonstrations of son preferences such as sex-selective abortion or infanticide and less extreme actions reflecting son preference is that less extreme measures exert their effects in a long-term, gradual, and piecemeal fashion. We need an indicator that is not overly sensitive to short-term changes, but is able to reflect the underlying long-term trend. Third, this measure should be able to capture information on vital aspects of human well-being, including health and nutritional status.

An indicator that meets these three criteria is children's height. Height is determined by biological factors as well as socioeconomic factors. While it is true that biological factors play an important role in determining children's genetic potential in height; it is also true that whether each child can fully achieve his/her genetic potential depends on nutrition, exposure to infectious diseases, and access to medical facilities (Alter 2004; Eveleth and Tanner 1990). Height deficits reflect cumulative exposure to poor nutrition and infectious diseases, such as diarrhea (Martorell and Habicht 1986; Pelletier 1998; Waterlow et al. 1977). If parents treat their male and female children differently regarding nutrition and care (especially medical care), regardless of whether it takes the form of shortened breastfeeding, insufficient parental care, or hard labor at early ages, the discriminatory treatment will likely be reflected in children's height. Also, unlike weight, which is sensitive to short-term fluctuations in nutritional intake and physical activities, height is resistant to influences of these short-term changes. Focusing on children's growth in height has another important advantage. Unlike many measurements used in social scientific research, children's height can be measured very accurately. With proper training and careful supervision, measurement errors can be reduced to a very low level when measuring children's height, especially when repeated measurements are taken (Willett 1989). It is important to note, though, that because of the prevalence of sex-selective abortion and infanticide in China our Chinese data will automatically exclude those girls would have been most disadvantaged, had they survived gestation and early life. Thus, our estimates of gender difference in children's growth in height in China should be interpreted as a lower bound of the true impact of son preference and gender inequality on the well-being of girls.

Based on the above discussions, we pursue a comparative analysis of China and the Philippines to assess the impact of son preference on children's health and wellbeing, as measured in growth in height. By doing this, we implicitly assume that level of son preference can be approximated at the country level (China versus the Philippines). Using national membership to serve as a proxy measure for some belief or behavior that is difficult to capture in survey data is a common practice in international comparative research. Given our prior knowledge of the two societies, we feel that it is reasonable to use Chinese and the Filipino families to represent environments reflecting relatively high and low son preference environments. We will answer the following research questions:

1. Are there gender differences in children's growth trajectories in both China and in the Philippines?
2. Are there differences in children's growth trajectories between China and the Philippines?
3. Do gender differences in children's growth trajectories differ between China and the Philippines? To be more specific, do Chinese boys have an advantage over Chinese girls in growth in height that is greater than Filipino boys' advantage over Filipino girls?
4. Do answers to the above questions depend on other factors, such as an urban-rural distinction?

Among the four research questions, questions 1 and 2 are exploratory in nature, in the sense that knowing their answers will help us better understand the underlying biological and socioeconomic processes that influence children's growth in height, but they are only peripheral to our central theoretical aim, and we do not have clear-cut research hypotheses for them. In fact, only question 3 speaks directly to our central theoretical aim, asking whether a higher level of son preference generates a higher level of gender inequality in children's health and wellbeing. An answer to question 4 can help us assess the robustness of our answer to question 3. We need to make sure that our statistical results reveal the underlying social processes, as opposed to a statistical artifact caused by insufficient control for relevant factors.

DATA AND METHODS

Data

In order to compare patterns of children's growth in height between China and the Philippines, we use data from two longitudinal surveys: the China Health and Nutrition Survey and the Cebu Longitudinal Health and Nutrition Survey. The China Health and Nutrition Survey (CHNS) was conducted by the Carolina Population Center at the University of North Carolina at Chapel Hill, the National Institute of Nutrition and Food Safety, and the Chinese Center for Disease Control and Prevention. The CHNS is a panel survey with a multistage clustered sample of 3,800 households in nine Chinese provinces, yielding a total of 16,000 selected individuals. Five waves of CHNS data are publicly available, collected in 1989, 1991, 1993, 1997, and 2000[2]. The CHNS includes a household survey, a community survey, a food market survey, and a health and family planning facility survey. Its household survey contains detailed physical examination information for both adults and children, which makes it ideal for the purposes of the current research.

The Cebu Longitudinal Health and Nutrition Survey (CLHNS) was conducted by the Carolina Population Center at the University of North Carolina at Chapel Hill, the Nutrition Center of the Philippines, the Office of Population Studies at the University of San Carlos, and

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[2] All five waves of data can be accessed at the CHNS project web site at: http://www.cpc.unc.edu/projects/china.

the Nutrition Center of the Philippines. A baseline survey (1983-1986) was conducted among 3,327 women during the 6th to 7th month of pregnancy living in 33 randomly selected communities from the Metropolitan Cebu area so that all impending births could be identified. Subsequent surveys took place immediately after birth, then at bimonthly intervals for 24 months; the baseline sample included 3,080 non-twin live births. Three follow-up surveys were conducted; in 1991-1992 (mean age 8 years, 74% of original sample), 1994-1995 (mean age 11.5 years, 71% of original sample), and 1998 (mean age 15.5 years, 68% of original sample). The CLHNS collected individual, household, and community information.

The CHNS project has released several longitudinal data sets by linking the five waves of public use data sets, including a longitudinal data set for anthropomorphic measurements. The CLHNS does not release data in such a longitudinal format; instead, we have linked the 15 data waves together by community and individual women's identification numbers. For the purposes of this analysis we have pooled the two data sets together to create a master longitudinal data set, and generated a binary variable that equals one if a case belongs to the Chinese sample and zero if it belongs to the Filipino sample.

Figure 1 and **Figure 2** show scatter plots of the measurement of height against age, for the CLHNS and the CHNS respectively. Note that both figures plot height by age without further differentiating by wave. One can easily jump to the conclusion that Figure 1 and Figure 2 look different, that Figure 1 is constituted by several disjointed clusters of dots while Figure 2 is constituted by one cluster and several outliers. But this difference is superficial, mainly an artifact of difference in research design between the CLHNS and the CHNS. The underlying patterns, roughly linear relationships between height and age, are very similar.

Variables

To maintain maximum comparability between the two different data sets, we extract and utilize a small number of variables in our analysis. The dependent variable is the physical measurement of the selected child's height (in centimeters).[3] We use the raw height measurement in our analysis instead of the widely used standardized *Z* score for reasons we will explain in detail in the next sections. The selected child's sex and age are the two central covariates. Age is a time-varying covariate that changes from wave to wave. In both the CHNS and the CLHNS, a child's exact age is computed by subtracting his/her date of birth from the date of measurement in each data collection wave. Sex is a time-constant dichotomous variable with male equals one and female equals zero, measured at baseline. We report wave-specific summary statistics of selected variables of CLHNS and the CHNS in Table 1 and Table 2.

The only control variable we include is a dichotomous variable indicating whether the community is classified as urban or rural. This variable is important for our analysis for several reasons. First of all, the urban-rural division is an important dimension of the stratification system in most developing countries, especially in China where an internal passport system (*hukou* system) designed to prevent rural-to-urban migration is in place (Wu and Treiman 2004). Urban residents work in non-agricultural jobs with relatively higher incomes, have access to

[3] Among CLHNS respondents, from birth through age two years height was measured as recumbent length (in millimeters) using a custom-designed length measuring board. During follow-up surveys standing height was measured using a portable stadiometer by trained project personnel in the child's home (Eckhardt, Gordon-Larsen and Adair 2005). Among the CHNS respondents, height was measured without shoes to the nearest tenth of a centimeter with a portable stadiometer (Popkin et al. 1995).

better food, schooling, and health facilities (Braveman and Tarimo 2002; Liu, Hsiao and Eggleston 1999; Popkin, Lu and Zhai 2002). As a result, the urban-rural division itself has important impacts on children's growth in height (Burgard 2002; Jin 2000; Reyes, Tan and Malina 2003). Second, a comparison of Table 1 and Table 2 reveals that while the Filipino sample is predominantly urban (more than 70% urban respondents), the Chinese sample is predominantly rural (more than 70% rural respondents). Since urban/rural place of residence is an important determinant of children's physical growth, it is important to ensure that our conclusions about patterns of growth in China and the Philippines are not confounded by the differences in population composition between these two samples.

Methodology

Individual growth modeling (IGM) is the natural analytical tool of choice for our research purposes. IGM is a form of multilevel analysis (Raudenbush 2001a; Singer and Willett 2003; Willett 1997). Let Y_{ti} be the measurement of height of child i at time t, where $t \geq 3$[4]. This child's growth trajectory in height can be modeled as a simple linear regression:

$$Y_{ti} = \pi_{0i} + \pi_{1i} AGE_t + r_{ti} \qquad (1)$$

where π_{0i} is the regression intercept that represents the initial height of child i at age zero; π_{1i} is the regression slope that represents the growth rate of child i over the period of data collection; they together determine the *growth trajectory* of height for that child.

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[4] Since we are estimating an OLS regression for each individual, three measurement points per person is the minimum requirement. However, individual growth model can handle the situation where some respondents have less than three measurement points. In this case, they will still be used in estimating the fixed effects but will be excluded in estimating the random effects.

Equation (1) states that child's growth in height is a *linear function* of age. By adding quadratic or other higher order terms of age, a more flexible growth curve can be approximated. The choice between alternative specifications of growth curves is an empirical one, in which a balance has to be reached between accuracy and parsimony. Equation (1) is a within-individual level equation that allows each child to have a distinct growth trajectory (the combination of the regression intercept and slope). Between-individual variation in growth trajectories can be modeled as:

$$\pi_{0i} = \beta_{00} + \mu_{0i} \tag{2}$$

$$\pi_{1i} = \beta_{10} + \mu_{1i} \tag{3}$$

where β_{00} represents the population average initial status, β_{10} represents the population average growth rate; μ_{0i} and μ_{1i} are child-level (between-individual) error components that follow a multivariate normal distribution with variances τ_{00} and τ_{11} and covariance τ_{01}. Covariates can be added into Equation (2) and (3) to test complex hypotheses that involve both within-level and cross-level interactions. Our core hypothesis, that gender inequality in children's growth in height is greater in China than in the Philippines, can be tested with the following equations:

$$\pi_{0i} = \beta_{00} + \beta_{01}BOY_i + \beta_{02}CHINA + \beta_{03}BOY \bullet CHINA + \mu_{0i} \tag{4}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}BOY_i + \beta_{12}CHINA + \beta_{13}BOY \bullet CHINA + \mu_{1i} \tag{5}$$

Equations (1), (4), and (5) constitute the backbone of the statistical analysis utilized in the present research. Both *MALE* and *CHINA* are dichotomous variables, indicating respondents' sex and country. All parameters in (4) and (5), both fixed and random parameters, are important because they reveal some aspects of the growth process: β_{00} represents Filipino girls' birth length; β_{01} represents the difference between Filipino boys' and girls' birth length; β_{02} represents the difference between Filipino girls and Chinese girls' birth length; and β_{03} represents a "difference in difference", that is, the difference in the gender difference in birth length between the Chinese and Filipino children. Similarly, β_{10} represents the growth rate in height of Filipino girls; β_{11} represents the difference in the growth rate between Filipino boys and girls; β_{12} represents the difference in the growth rate between Filipino and Chinese girls; and β_{13} represents the difference in the gender difference in growth rate between Chinese and Filipino children. Researchers from different disciplines may be interested in different coefficients from this model. As social scientists, our central theoretical interest focuses primarily on one coefficient, the "difference in difference" coefficient for the growth rate β_{13}, which represents added male advantage in growth that we hypothesize is due to stronger son preference in China. We hypothesize that β_{13} is significantly greater than zero.

There are several pertinent issues that arise in estimating these multilevel individual growth models. In contrast to some previous studies, we use raw height measurements instead of the standardized *Z* score. The *Z* score must be used when working with cross-sectional data. This is because cross-sectional data do not contain enough growth information to allow conclusions about the pattern and process of growth without borrowing information from outside the data being used. In the case of Z scores, information is borrowed from growth charts that describe age- and sex-specific patterning of growth among a population's children. A *Z* score represents a given child's deviation from the average height of a child of the same age and sex. With longitudinal data and growth modeling methodology, however, utilizing a standardized *Z* score is not only unnecessary, but problematic. One of the fundamental requirements of growth modeling is that the measurement must be equitable from occasion to occasion (Willett 1997); for this reason, standardizing raw measurements to a gender- and age-specific standard score jeopardizes the cross-wave compatibility. The reason is simple: the mean and standard deviation of height is age-specific. In other words, even in the "reference" population from which the standardized score is drawn, both the mean and standard deviation of height vary from age to age. Unless the standardization is based on a single age group for each sex (which makes no sense because it is then no longer "sex- and age-specific"), the calculation of the standardized *Z* score is based on different means and standard deviations in different age groups, and the resulting *Z* score no longer retains cross-wave comparability.

Centering is also an important issues in multilevel analysis (Kreft, de Leeuw and Aiken 1995). We choose not to center *AGE*, our only level-1 covariate, mainly because age zero is a meaningful starting point in our analysis. The distinction between initial height status and growth rate is of direct theoretical relevance to our purposes. It is safe to assume that any gender difference in birth height (the initial status) is mainly attributable to biological and genetic reasons, given that the ultrasound technology that can be used to find out a fetus' sex was not widely available in China or the Philippines until the end of the 1980s (Chu 2001). Once the baby is born, non-biological and non-genetic factors influencing growth begin to take effect: parents with a strong son preference pay much more attention to the needs of baby boys then baby girls, while parents with weak or no son preference pay relatively equal attention to a child regardless of sex. It is at this stage (after the baby is born) that we expect to see a significant difference between China and the Philippines, two countries with different cultural traditions regarding parents' preferences for sons and daughters.

Individual growth models based on multilevel methodology are very flexible in handling complicated data structures including an unequal number of time series data points across individuals and variable spacing of time points across individuals (Hox 2002; Raudenbush 2001b; Singer and Willett 2003). This is one of the major reasons that we chose these models over alternatives. Like many other longitudinal data sources, both the CHNS and the CLHNS suffer from panel attrition. In fact, only 58% of the Filipino children in the CLHNS have all 16 observations, and only 27% of the Chinese children in the CHNS have all 5 observations. Unlike alternative statistical methodologies (*MANOVA*, for example) that simply exclude respondents without complete observations, individual growth models utilize all available observations in coefficient estimation. This not only increases efficiency and reliability of parameter estimates, but also avoids potential biases caused by nonrandom sample selection. Individually varying time points of observation is another characteristic of the CHNS. Some children enter the study after birth, while others enter at much older age. In theory, each child may have a unique observational schedule. Individually varying time points of observation is less of a problem in the CLHNS, at least for the first 13 data waves. But the fact that the first 13 data waves cluster within the first two years while the last three data waves spread over the remaining 15 years poses another interesting challenge. Fortunately, by including age as a level-1 covariate, multilevel individual growth models can accommodate both situations.

ANALYSIS

We begin our analysis by summarizing gender- and age-specific heights separately for Chinese and Filipino children. We then examine the empirical growth pattern in height, which helps us assess the adequacy of simple linear regression in fitting individual-level growth trajectory. As the final step, we combine the Chinese and Filipino samples and estimate a series of linear individual growth models[5].

Describing Gender Difference in Children's Growth in Height

Table 3 reports gender- and age-specific summary statistics of children's height using the Filipino CLHNS sample. There are several things worth noting; first, the summary statistics are based on age instead of wave; here it is possible that more than one data wave was used in calculating summary statistics of height for an age group. Second, even though the CLHNS has a total of 16 data waves, 13 of them are concentrated within the first two years of life (at bimonthly intervals), while there are only three waves during the final 15 years (this can be clearly seen in **Figure 1**). This has two implications: on the one hand, the summary statistics for the first two years of age are very accurate and reliable, due to the large number of cases encapsulated in these age categories; on the other hand, the rest of the age categories are relatively sparse, many of them are even empty. Also, boys and girls were interviewed separately in the last wave. Girls were interviewed during 1998 and 1999, while boys were interviewed during 1999 and 2000. This is reflected in Table 3: there are 64 girls at age 16 and zero at age 17, while there are only 43 boys at age 15 and zero at age 14. This peculiar data structure does not pose special difficulties for the multivariate analysis since multilevel individual growth modeling is very flexible in handling complicated data structures (Raudenbush 2001b; Singer and Willett 2003), but it makes the descriptive analysis challenging.

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[5] We combine the Chinese and the Filipino data sets and conduct one model instead of two separate models for each of the countries mainly because we want to explicitly test statistical significance of the interaction terms that involve *CHINA*, our dichotomous country indicator.

Table 4 reports similar gender- and age-specific summary statistics using the Chinese CHNS sample. The distribution of observations among different age groups is much more even than that in the CLHNS (compare **Figure 1** and **Figure 2**). In this sample, it is even more likely that observations from multiple data waves are used in calculating summary statistics for one age group.

Since our goal is to compare gender difference in height, we calculated the difference in mean gender difference in height for the Filipino sample in Table 3 and for the Chinese sample in Table 4. We then plot the two age-specific differences in height against age in **Figure 3**. Note that in order to ease the inspection, both lines in the figure have been smoothed using locally weighted regression (*lowess*) (Cleveland 1979). This figure suggests several things; first of all, the gender difference in children's height is *always* higher in China than in the Philippines. Second, the Filipino summary is much less stable than the Chinese. After adjusting bandwidth of the *lowess* smoother to 2, the Chinese line has become very smooth but the Filipino line remains more erratic. Third, Chinese boys are always taller than Chinese girls, while Filipino boys are shorter than Filipino girls at certain ages, from about age eight to 13.

Describing the Empirical Growth Trajectory

Although the linear growth model is most widely used in empirical research, it has to be emphasized that linearity is a rather strong assumption that may or may not be realistic in certain research situations. Before estimating a linear growth model, one need to make sure that the individual growth trajectory can be described as linear without deviating too far from the data.

Figure 4 shows empirical growth trajectories of four Filipino children as well as predicted values from simple linear regressions. It reveals four typical situations seen in the data. Dots represent observed height values while lines represent fitted linear regression. The upper left panel (ID=10044) represents those children who were measured in the first two years (the 12 bimonthly surveys) after birth but dropped out of the three follow-up surveys. The lower left panel (ID=10069) represents those children who were not measured in the first two years but were included in the three follow-up surveys. The lower right panel (ID=20117) represents those children who were measured in both the twelve bimonthly surveys and the three follow-up surveys. The upper right panel (ID=10069) is one of the children with complete data from the three follow-up interviews but only some (but not all) measurements from the twelve bimonthly interviews. In all four cases, a within-person linear regression model does provide reasonable fit to the growth data, although the fit is better in some cases (ID=10069, 20046) than in others (ID=10044, 20117)[6]. The CHNS data has a simpler structure, and **Figure 5** shows four representative Chinese respondents. Although the number of observation varies from respondent to respondent for various reasons, an approximately linear growth trajectory fits well in all four cases.

Results from Multilevel Individual Growth Models

We follow the model-building strategy suggested by Singer and Willett (2003) by beginning with an unconditional means model, and gradually build the model. We report five individual growth models in Table 5. Model 1 is an unconditional means model with only one fixed effect (the grand mean) and two random effects (variances for the level-1 residual and level-2 intercept). This model can serve the purpose of partitioning the outcome variation. Several

[6] We inspected empirical growth trajectories of a large number of children in both the CLHNS and the CHNS. Except for a few outliers, our conclusion about the applicability of linear growth trajectory holds in both samples.

important conclusions can be drawn from this simple model. First of all, the two significant random components reveal that average children's height varies over time (within individual) and differs across individuals. The logical next step is to include both level-1 and level-2 covariates into the model and predict that some of the within- and between-individual variation are explained. The unconditional means Model 1 can also be used to calculate the intraclass correlation coefficient, which describes the proportion of the total outcome variation that lies between individuals. In our case, the intraclass correlation is calculated as .42 (19.47/(19.47+26.64)). The fixed effect estimated in this model is not very interesting, because it constrains every individual's growth trajectory to be a flat line.

Model 2, the unconditional growth model, adds one more fixed effect parameter and two more random effect parameters to Model 1. By adding *AGE* (intercept for the rate of change) into the model, Model 2 has been extended into a real growth model where the individual's growth trajectory is determined by an initial status as well as a growth rate. The new parameters significantly change parameter estimation compared to Model 1. The intercept for initial status declines from 95.4 to 64.9, the level-1 residual declines from 26.4 to 5.5, and the level-2 variance for the intercept declines from 19.5 to 4.9, though all of these terms are still statistically significant at the level of $p<.05$. According to the *AIC* and *BIC*, Model 2 fits the data considerably better than Model 1. The correlation of .49 (level 2 covariance) between the two level-2 variance components shows that babies who are "taller" at birth grow faster than babies with shorter birth height.

Model 3 further extends Model 2 by adding four more fixed effect parameters: *MALE* and *CHINA* into both the initial status equation and the growth rate equation. Comparing parameter estimates in Models 2 and 3 shows that adding new fixed parameters does not significantly change point estimates of existing covariates, but they do improve the model fit, as revealed by AIC and BIC. Model 3 can be used to answer our research questions 1 and 2: in both China and the Philippines, newborn boys are on average 1.43 cm longer than newborn girls, but they grow slight slower (-.08 cm per year); for both boys and girls, those who were born in China are 9.20 cm longer than those who were born in the Philippines, but they grow slightly slower (.13 cm per year). Controlling for the included covariates, babies with longer birth length are likely to grow faster than those with shorter birth length, as indicated by the correlation between the two level-2 variance components (.72).

Model 4 adds two more fixed effect parameters to Model 3: the interaction between *CHINA* and *MALE*, for both the initial status and the growth rate. This model can be used to tackle the central research question about whether son preference has significant impact on gender difference in growth in height. Adding new parameters has little impact on the point estimates of existing covariates, for both fixed and random effects. For the initial status, Filipino boys are 1.34 cm longer than girls on average at birth, while Chinese boys are only .98 (1.34-.36) cm longer than girls at birth. The difference between Chinese and Filipinos in gender difference in birth length is not statistically significant at the level of .05. For the growth rate, we can see that Filipino boys grow significantly slower than Filipino girls (-.13 cm per year), while Chinese boys grow slightly faster than Chinese girls (.15-.13=.02 cm per year), the difference between Chinese and Filipinos in gender difference in growth rate is statistically significant at the level of .05. In the Philippines, boys are born longer than girls but grow more slowly. In China, boys are not only born longer than girls, but also grow faster. This result is consistent with our central theoretical argument that a higher level of son preference increase the advantages of boys over girls in health and wellbeing.

As we mentioned earlier, our Filipino data is primarily an urban sample while our Chinese data is primarily a rural sample. Without controlling for this difference a competing explanation of the observed pattern, that the revealed pattern of gender difference in children's growth trajectories is is accounted for by urban-rural differences between samples, cannot be ruled out. To make our conclusion more robust, we estimate Model 4, which is Model 3 with two more fixed effect parameters for *URBAN* in the initial status equation and in the rate of change equation. We find that controlling for the urban-rural differences across the two country samples has little impact on point estimates of both fixed and random effect parameters. There is no significant urban-rural difference in children's birth length; but urban children do grow faster than rural children. Adding new covariates improves model fit slightly, based on both AIC and BIC.

Discussion

Son preference is one of the major forms of discrimination in human society that has important impacts on women's health and wellbeing. Previous research on this topic focuses almost exclusively on the linkage between son preference, sex-selective abortion and infanticide, and imbalanced sex ratios. Much less is known about the detrimental effects of some less extreme actions influenced by son preference on individual health and wellbeing. There is a gap in existing literature; on the one hand, we know that son preference make girls worse off in various ways (Graham et al. 1998; Short et al. 2001), but we do not know what the long-term consequences of these acts are. On the other hand, we know that height deficits in early childhood have serious negative implications for school performance and labor market position in later life (Daniels and Adair 2004; Glewwe, Jacoby and King 2001; Jamison 1986), but we do not know how relevant this is in explaining the observed gender difference in life achievements.

Our research offers some evidence to bridge the life course gap between the above-mentioned two lines of research. By showing that son preference generates gender differentiated growth trajectories in height, we help to create a more complete life course picture of how gender inequality is produced and reproduced from life stage to life stage and across generations.

References

Alter, G. 2004. "Height, Frailty, and the Standard Of Living: Modeling the Effects of Diet and Disease on Declining Mortality and Increasing Height." *Population Studies* 58:265–279.

Banister, J. 2004. "Shortage of Girls in China Today." *Journal of Population Research* 21:19-45.

Bautista, M.L. 1988. "Historical Influences on Gender Preference in the Philippines." *Journal of Comparative Family Studies* 9(1):143-153.

Braveman, P.and E. Tarimo. 2002. "Social Inequalities in Health within Countries: Not Only an Issue for Affluent Nations." *Social Science and Medicine* 54:1621-1635.

Burgard, S. 2002. "Does race matter? Children's height in Brazil and South Africa." *Demography* 39(4):763-790.

Chu, J. 2001. "Prenatal Sex Determination and Sex-Selective Abortion in Rural Central China." *Population and Development Review* 27:259-281.

Cleveland, W.S. 1979. "Robust Locally Weighted Regression and Smoothing Scatterplots." *Journal of the American Statistical Association* 74:829-836.

Daniels, M.C.and L.S. Adair. 2004. "Growth in Young Filipino Children Predicts Schooling Trajectories through High School." *Journal of Nutrition* 134:1439-1446.

Davis, D.and S. Harrell. 1993. "Introduction: The Impact of Post-Mao Reforms on Family Life." in *Chinese Families in the Post-Mao Era*, edited by D. Davis and S. Harrell. Berkeley: University of California Press.

De Vos, S. 1985. "An Old-Age Security Incentive for Children in the Philippines and Taiwan." *Economic Development and Cultural Change* 33(4):793-814.

Estudillo, J.P., A.R. Quisumbing, and K. Otsuka. 2001. "Gender Differences in Land Inheritance, Schooling, and Lifetime Income: Evidence from the Rural Philippines." *The Journal of Development Studies* 37(4):23-48.

Eveleth, P.B.and J.M. Tanner. 1990. *Worldwide Variation in Human Growth*. Cambridge; New York: Cambridge University Press.

Glewwe, P., H.G. Jacoby, and E.M. King. 2001. "Early Childhood Nutrition and Academic Achievement: A Longitudinal Analysis." *Journal of Public Economics* 81:345-368.

Graham, M.J., U. Larsen, and X. Xu. 1998. "Son Preference in Anhui Province, China." *International Family Planning Perspectives* 24:72-77.

Hox, J.J. 2002. *Multilevel Analysis: Techniques and Applications*. Mahwah, N.J.: Lawrence Erlbaum Associates.

Hudson, V.M.and A.M.d. Boer. 2004. *Bare Branches: the Security Implications of Asia's Surplus Male Population*. Cambridge, Mass.: MIT Press.

Jamison, D.T. 1986. "Child Malnutrition and School Performance in China." *Journal of Development Economics* 20:299-309.

Jin, S. 2000. "Changing Nutritional Status of Preschool Children – The Recent Experience in China." *Malaysian Journal of Nutrition* 6:197-202.

Kreft, I.G., J. de Leeuw, and L.S. Aiken. 1995. "The Effect of Different Forms of Centering in Hierarchical Linear Models." *Multivariate Behavioral Research* 30:1-21.

Lee, J.Z.and W. Feng. 1999. *One Quarter of Humanity: Malthusian Mythology and Chinese Realities, 1700-2000*. Cambridge, Mass.: Harvard University Press.

Lee, J.Z.and F. Wang. 1999. *One Quarter of Humanity: Malthusian Mythology and Chinese Realities, 1700-2000*. Cambridge, Mass.: Harvard University Press.

Li, J. 2004. "Gender Inequality, Family Planning, and Maternal and Child Care in a Rural Chinese County." *Social Science and Medicine* 59:695-708.

Li, N., M.W. Feldman, and S.Z. Li. 2000. "Cultural Transmission in a Demographic Study of Sex Ratio at Birth in China's Future." *Theoretical Population Biology* 58:161-172.

Liu, Y., W.C. Hsiao, and K. Eggleston. 1999. "Equity in Health and Health Care: the Chinese Experience." *Social Science and Medicine* 49:1349-1356.

Martorell, R.and J.P. Habicht. 1986. "Growth in Early Childhood in Developing Countries." in *Human Growth: A Comprehensive Treatise, Volume 3,* edited by F. Falkner and J.M. Tanner. New York: Plenum Press.

Mason, K.O. 1987. "The Impact of Women's Social Position on Fertility in Developing Countries." *Sociological Forum* 2:718-745.

Merli, M.G.and A.E. Raftery. 2000. "Are Births Underreported in Rural China? Manipulation of Statistical Records in Response to China's Population Policies." *Demography* 37:109-126.

Pelletier, D.L. 1998. "Malnutrition, Morbidity, and Child Mortality in Developing Countries." in *Too Young to Die: Genes or Gender?* New York: United Nations.

Popkin, B.M., B. Lu, and F. Zhai. 2002. "Understanding the Nutrition Transition: Measuring Rapid Dietary Changes in Transitional Countries." *Public Health Nutrition* 5(6A):947-953.

Popkin, B.M., S. Paeratakul, K.Y. Ge, and Z. Fengying. 1995. "Body-Weight Patterns among the Chinese - Results from the 1989 and 1991 China Health and Nutrition Surveys." *American Journal of Public Health* 85(5):690-694.

Quisumbing, A.R. 1994. "Intergenerational Transfers in Philippine Rice Villages: Gender Differences in Traditional Inheritance Customs." *Journal of Development Economics* 43(2):167-195.

Raudenbush, S. 2001a. "Comparing Personal Trajectories and Drawing Causal Inferences from Longitudinal Data." *Annual Review of Psychology* 52:501-525.

Raudenbush, S.W. 2001b. "Toward a Coherent Framework for Comparing Trajectories of Individual Change." Pp. 33-64 in *New Methods for the Analysis of Change*, edited by L.M. Collins and A. Sayer. Washington, DC: American Psychological Association.

Ren, X.S. 1995. "Sex Differences In Infant And Child Mortality In Three Provinces In China." *Social Science and Medicine* 40:1259-1269.

Reyes, M.E.P., S.K. Tan, and R.M. Malina. 2003. "Urban-Rural Contrasts in the Growth Status of School Children in Oaxaca, Mexico." *Annals of Human Biology* 30:693-713.

Short, S.E.and F. Zhai. 1998. "Looking Locally at China's One-Child Policy." *Studies in Family Planning* 29:373-387.

Short, S.E., F. Zhai, S. Xu, and M. Yang. 2001. "China's One-Child Policy and the Care of Children: An Analysis of Qualitative and Quantitative Data." *Social Forces* 79:913-943.

Singer, J.D.and J.B. Willett. 2003. *Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence*. Oxford ; New York: Oxford University Press.

Waterlow, J., R. Buzina, W. Keller, J. Lane, M. Nichaman, and J. Tanner. 1977. "The Presentation and Use of Height and Weight Data for Comparing the Nutritional Status of Groups of Children Under the Age of Ten Years." *Bulletin of the World Health Organization* 55:489-498.

Willett, J.B. 1989. "Some Results On Reliability For The Longitudinal Measurement Of Change: Implications For The Design Of Studies Of Individual Growth." *Educational and Psychological Measurement* 49:587-602.

—. 1997. "Measuring Change: What Individual Growth Modeling Buys You." Pp. 213-243 in *Change and Development: Issues of Theory, Method, and Application*, edited by E. Amsel and K.A. Renninger. Mahwah, NJ: Lawrence Erlbaum Associates.

Wu, X.and D.J. Treiman. 2004. "The Household Registration System and Social Stratification in China: 1955-1996." *Demography* 41:363-384.

Figures

Figure 1: Distribution of Filipino Children's Height by Age

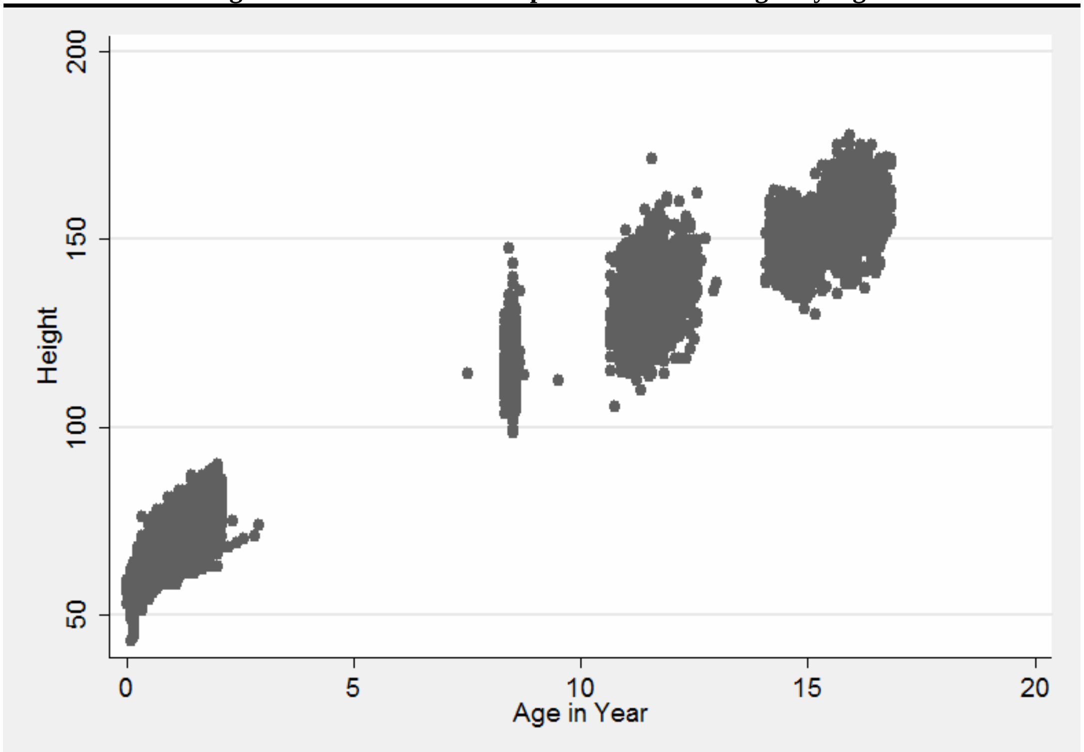


Figure 2: Distribution of Chinese Children's Height by Age

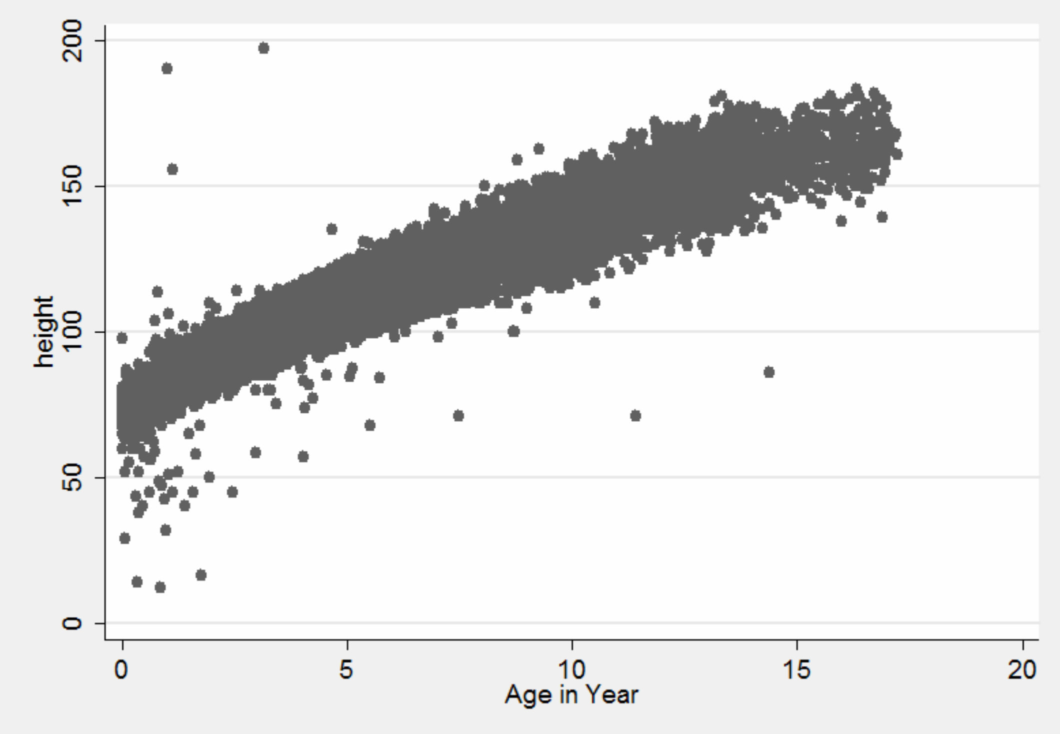


Figure 3: Smoothed Age-Specific Difference in Mean Height between Boys and Girls

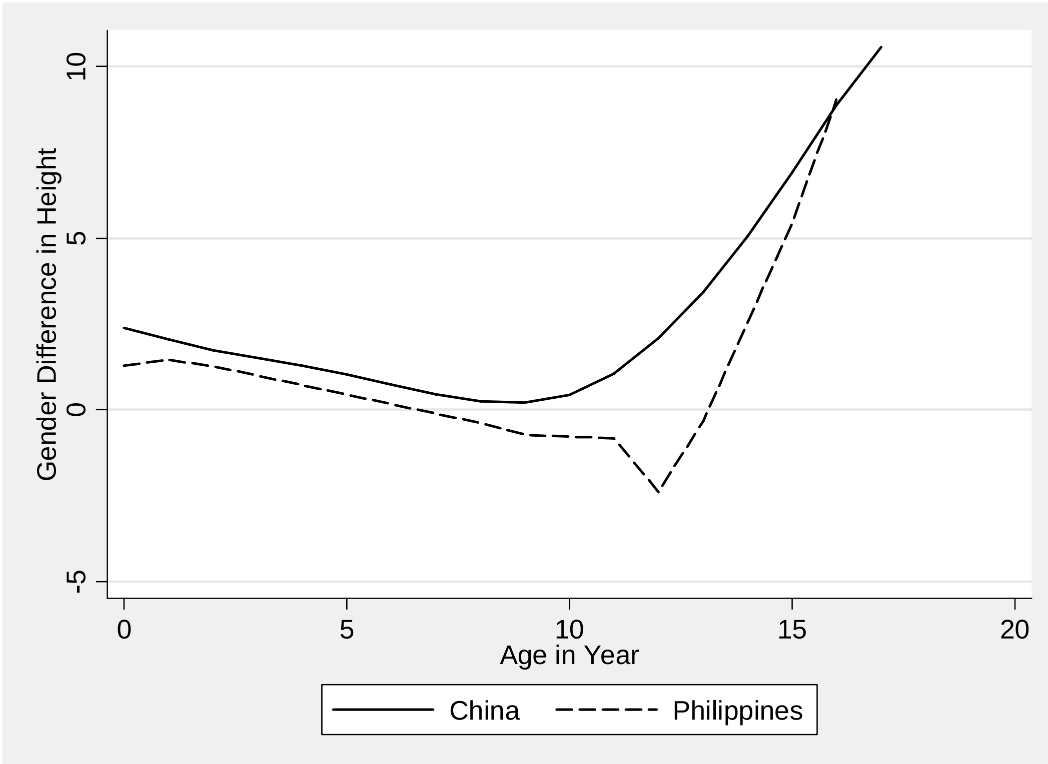


Figure 4: Empirical and Linear Growth Trajectories of Selected Filipino Children

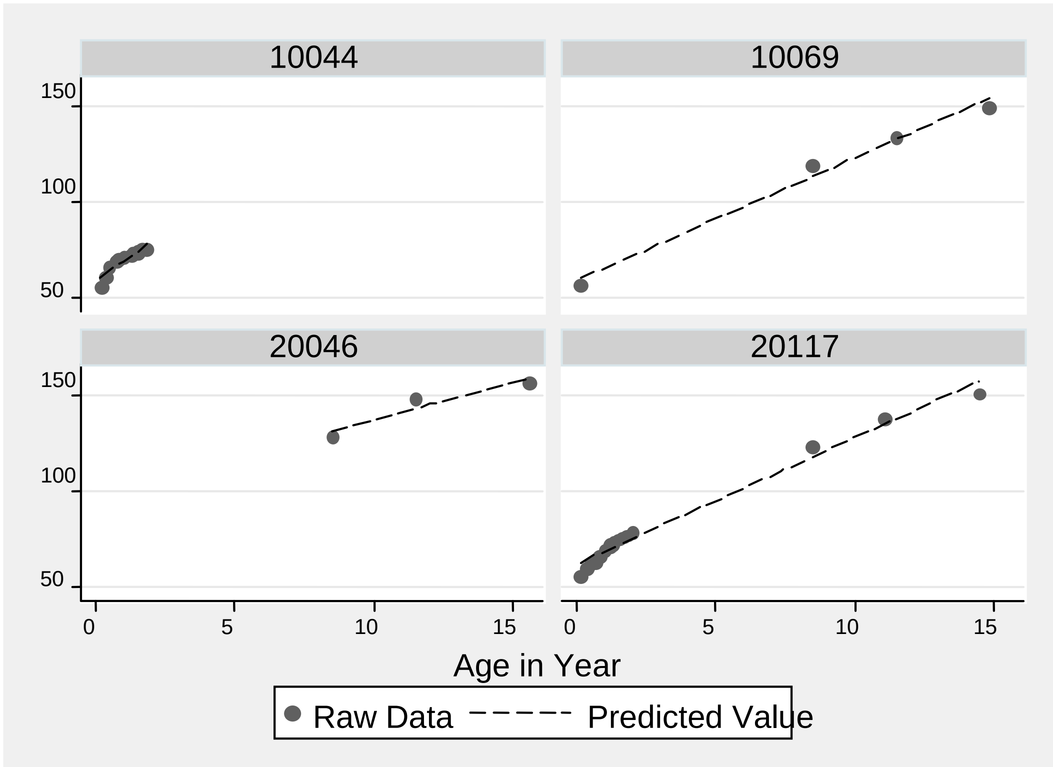
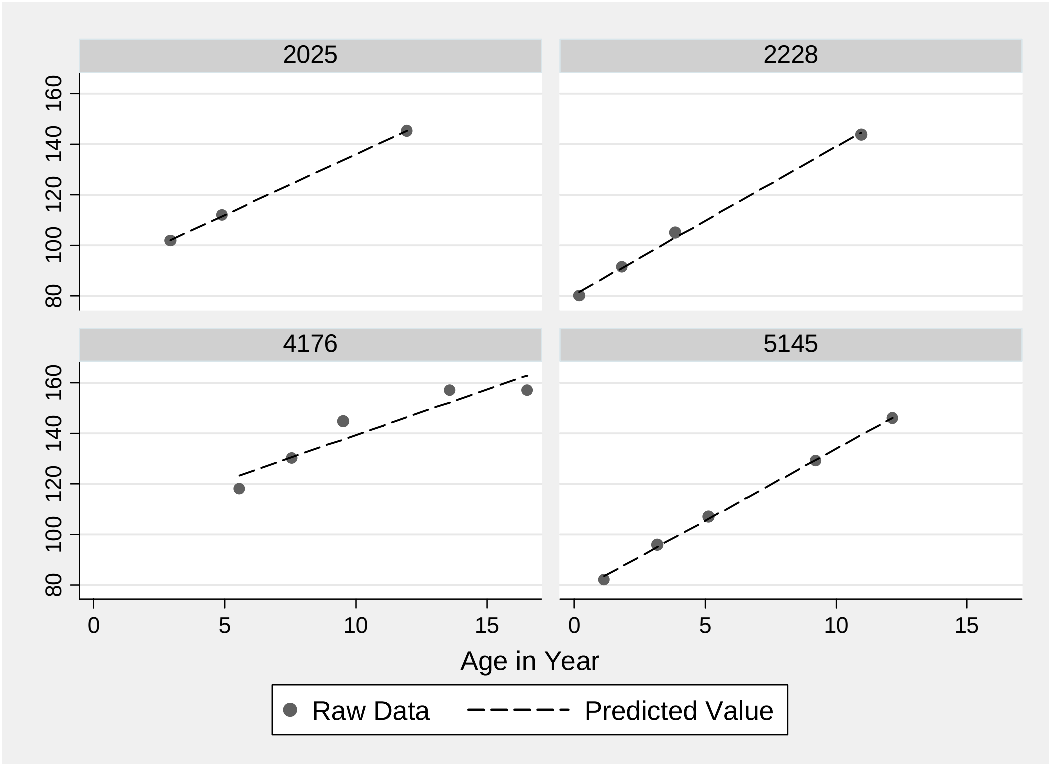


Figure 5: Empirical and Linear Growth Trajectories of Selected Chinese Children



Tables

Table 1: Cross-Wave Comparison of Selected Variables in the CLHNS

	Height (cm)	Age (Year)	% Male	% Urban
At Birth	49.33	0	53	76
2nd Month	56.38	.16	53	76
4th Month	61.11	.33	53	75
6th Month	64.34	.49	53	75
8th Month	66.86	.66	53	75
10th Month	69.01	.82	53	75
12th Month	70.81	.99	53	75
14th Month	72.40	1.16	53	75
16th Month	73.81	1.32	53	75
18th Month	75.21	1.49	53	75
20th Month	76.57	1.66	53	75
22nd Month	77.81	1.82	53	75
24th Month	79.18	1.99	53	75
1991 Follow-up	117.70	8.49	53	74
1994 Follow-up	133.78	11.52	52	73
1998 Follow-up	154.01	15.50	52	72

Table 2: Cross-Wave Comparison of Selected Variables in the CHNS

	Height (cm)	Age	% Male	% Urban
1989 Wave	89.79	2.71	53	30
1991 Wave	100.55	4.12	53	29
1993 Wave	109.76	5.53	53	29
1997 Wave	125.50	8.16	53	29
2000 Wave	134.76	9.75	53	29

Table 3: Age-Specific Mean and Standard Deviation of Height, and Number of Observations from CLHNS, Differentiated by Sex

Age*	Female			Male		
	Mean	S.D.	N	Mean	S.D.	N
0	55.16	5.35	4,177	56.16	5.75	4,748
1	68.81	4.29	7,062	70.34	4.33	7,856
2	76.34	3.81	4,200	77.98	3.71	4,642
3	71.67	2.08	3			
8	118.07	5.86	231	117.89	5.27	272
9	117.58	5.59	818	117.68	5.63	900
10	112.20		1			
11	133.33	7.33	463	130.50	6.56	518
12	136.83	7.58	571	133.84	6.95	619
13	140.69	8.27	13	136.89	11.30	11
14	148.83	5.44	117			
15	149.02	5.56	791	156.26	7.10	43
16	150.49	5.59	64	158.49	6.74	884
17				159.23	6.65	132

Table 4: Age-Specific Mean and Standard Deviation of Height, and Number of Observations from CHNS, Differentiated by Sex

Age*	Female			Male		
	Mean	S.D.	N	Mean	S.D.	N
0	72.64	7.68	157	74.93	6.95	177
1	80.64	8.67	373	82.62	8.87	443
2	88.46	7.44	401	90.48	5.62	461
3	96.08	5.41	446	97.58	7.23	530
4	102.73	6.10	460	103.27	6.37	510
5	108.86	5.82	445	109.68	6.39	539
6	114.31	6.65	427	115.88	6.82	459
7	120.39	7.21	413	121.09	6.83	457
8	125.93	7.21	342	126.37	7.02	408
9	132.20	8.18	323	131.80	8.04	380
10	137.14	8.83	330	136.06	8.23	341
11	143.75	9.90	247	143.06	8.33	303
12	149.66	7.74	231	149.63	9.60	253
13	152.86	6.81	232	154.59	10.43	250
14	155.00	8.30	178	160.74	8.88	199
15	156.77	6.00	78	164.21	6.87	79
16	157.46	6.60	69	168.34	7.35	73
17	160.23	6.20	35	169.01	6.19	40

Table 5: Linear Growth Model of Children's Growth in Height in China and the Philippines

	Model 1	Model 2	Model 3	Model 4	Model 5
Fixed Effects					
Initial Status					
Intercept	95.44	64.86	60.85	60.89	60.82
	(.28)	(.07)	(.08)	(.08)	(.12)
Male			1.43	1.34	1.34
			(.10)	(.12)	(.12)
China			9.20	9.39	9.44
			(.13)	(.19)	(.20)
Urban					.09
					(.11)
China × Male				-.36	-.34
				(.26)	(.26)
Rate of Change					
Intercept		6.38	6.26	6.29	6.17
		(.01)	(.01)	(.01)	(.02)
Male			-.08	-.13	-.13
			(.02)	(.02)	(.02)
China			-.13	-.21	-.14
			(.02)	(.03)	(.03)
Urban					.17
					(.02)
China × Male				.15	.16
				(.04)	(.04)
Variance Components					
Level-1 Residual	26.64	5.45	5.47	5.47	5.47
	(.09)	(.02)	(.02)	(.02)	(.02)
Level-2: Intercept	19.47	4.86	2.58	2.58	2.58
	(.25)	(.09)	(.06)	(.06)	(.06)
Level-2: Age		.36	.36	.36	.35
		(.01)	(.01)	(.01)	(.01)
Lavel-2: Covariance		.49	.72	.73	.73
		(.05)	(.04)	(.04)	(.05)
Log Likelihood	-243283.1	-165832.5	-163487.3	-163478.5	-163421.4
Degrees of Freedom	3	6	10	12	14
AIC	486572.3	331677	326994.6	326981	326870.9
BIC	486598.8	331730	327082.9	327087	326994.6
N of Groups	7532	7532	7532	7532	7532
N of Observations	50717	50717	50717	50717	50717